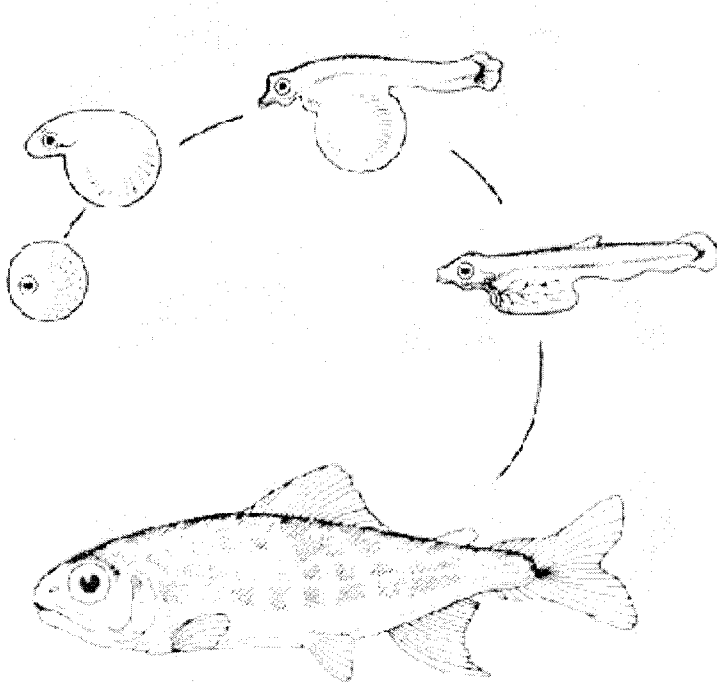
Protection of Wild Adult Steelhead in Idaho by Adipose Fin Removal

Final Report
1985 - 1988



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PROTECTION OF WILD ADULT STEELHEAD IN IDAHO BY ADIPOSE FIN REMOVAL

Final Report

By

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ABSTRACT

Steelhead trout (Salmo gairdneri) reared in Idaho hatcheries for release during the 1984-1988 outmigrations were adipose fin clipped to differentiate between wild/natural and hatchery-reared fish. From 1984- 1988, 34 million hatchery-reared steelhead trout were clipped and 30.1 million were released; the difference being made up by hatchery mortality and the percent of acceptable clips. Since 1987, the adipose clip has given protection to all wild/natural steelhead and identified them from hatchery stocks.

It is premature to conclude whether adipose marking can be totally effective in preserving wild runs into Idaho. Although wild runs appear to be increasing, the full effect of this program cannot be evaluated until the mid-1990s, when sufficient numbers of year classes will have returned to provide significant data. In the interim, the program is successfully protecting wild stocks from being harvested in Idaho's sport fishery. This program, if continued, will undoubtedly reduce harvest mortality of wild stocks and enhance their restoration.

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INTRODUCTION

In the early 1980s, the improved survival of hatchery-reared steelhead created stock management problems. While adequate numbers of hatchery-reared fish led to harvestable surpluses, wild stocks remained at low levels. Angler harvest directed at hatchery stocks led to overharvest of wild stocks. In order to harvest surplus hatchery stocks and protect wild stocks in the fishery, anglers needed a means of identifying between the two at the time the fish were caught. Initially, various dorsal fin length criteria were used to regulate harvest. These were not totally successful because of variability and enforcement difficulties. To solve the problems associated with differential harvest, fishery scientists decided to desequester the adipose fin clip previously used to identify the presence of a coded wire tag and use it as a harvest identifier. All hatchery-reared steelhead in the Columbia River Basin were to be adipose clipped.

On November 1, 1983, the Idaho Department of Fish and Game secured a five-year contract from Bonneville Power Administration (BPA) to adipose clip all of the hatchery-reared steelhead in Idaho to aid in the protection of Idaho's wild stocks. This report summarizes that work.

OBJECTIVES

The objectives of the project were:

1. To remove 751 of the adipose fins from 99% of the hatchery-reared steelhead in Idaho.

2. To review current information on the use of adipose fin clipping.

3. To determine, if possible, the physiological role of the adipose fin.

METHODS

From 1983 to 1987, fish marking operations were conducted at three Idaho steelhead production facilities: Niagara Springs (Idaho Power), Hagerman National, and Dworshak National fish hatcheries. In 1987, the Magic Valley Fish Hatchery was put into production, and all fish were marked for release in the spring of 1988.

Except for the first year, all marking was conducted in two specially built mobile marking units. These units were constructed in 1984 specifically for the large marking operations previously handled by various departmental and federal marking trailers. The new marking units each contain 16 work stations and efficiently handle large numbers of fish with minimal stress (Duke 1985).

Inside the trailers, fish were placed in troughs containing a solution of MS-222, Propolyaqua, and anti-foam. The solution was recirculated, cooled, and aerated. MS-222 is an anesthetic, Propolyaqua is a stress reducer, and anti-foam prolongs the effect of the anesthetic solution. Once the fish are anesthetized, personnel remove the adipose fin with scissors.

Quality inspections were taken throughout the marking operation to ensure that the clip was being done properly and that all fish were clipped. Prior to release, a minimum 300 fish were visually examined to determine the quality of the clip. Examined fish were divided into five categories based on their fin clip: excellent (100% removal); too deep (100% removal, but secondary infections or complications possible); poor (less than 10% remaining at the leading edge); partial (10-251 remaining); and not clipped (more than 251 remaining). All clip categories, except "not clipped," are acceptable to be used in identifying returning adult fishes.

Fish health was monitored throughout the rearing cycle and mortalities noted. Mortality attributable to marking was calculated by subtracting the daily mortality before marking began from the mortality level after marking until the mortality rate stabilized at pre-marking levels. In some cases, rearing histories from the previous year were used to estimate the normal daily mortality rate for that particular stage of rearing.

In 1985, in vivo experiments on healing rate were conducted at Dworshak National Fish Hatchery. Both unclipped (control) and clipped (test) fish were held in circular vats. Idaho Department of Fish and Game personnel monitored the tests and documented the healing process photographically. Samples of juvenile and adult adipose fins were sent to the U.S. Fish and Wildlife Service's Cultural Development Center where Charlie E. Smith examined histological sections for tissue composition.

Extensive reviews of literature on hooking mortality rates, the use of the adipose fin marking system in the protection of wild fish, adipose fin function and composition, and effects of fin clipping on survival were gathered from various sources and were included in a previous annual report (Duke 1986). They have also been included at the end of this report.

In 1986, fish from the first ad-clip marking operation returned to Idaho. Returning one-salt adult steelhead were monitored to determine the quality and degree of regeneration of the adipose clip. In the fall of 1987 and spring of 1988, a more extensive check of adult clip quality was conducted in both the sport fishery and at the spawning racks. Hatchery and wild compositions were determined as the fish passed through various adult monitoring facilities located at selected hydroelectric projects. This was the first year that all fish in the three returning age classes were adipose clipped under this marking program.

RESULTS

1987-1988 Mark Operations

Clipping for the final year of this project began on September 8, 1987 at Niagara Springs Steelhead Hatchery and continued until October 1, 1987. A total of 2,300,818 hatchery steelhead were clipped. The marking operation was then moved to Hagerman National Fish Hatchery from October 5 until October 23, 1987, where 1,986,060 steelhead were clipped. Steelhead were clipped at the Magic Valley Steelhead Hatchery during the period October 27 through November 20, 1987. A total of 2,116,071 steelhead were marked at Magic Valley.

The same marking personnel were used at all three facilities. Crews worked two 6-hour shifts in a single mobile marking unit. A total of 554 hours (about 47 days) were required to mark the 6.4 million fish at the three hatcheries, representing an average of 11,645 fish clipped per hour at the three facilities.

Due to the number of fish marked at Hagerman, Niagara, and Magic Valley, marking at Dworshak was delayed until December 1987. Consequently, Dworshak's fish nearly exceeded the optimum marking size. This, coupled with the large number of fish at Dworshak, presented major challenges in order to complete the operation before the January 1 cutoff date for marking at the facility. In order to complete marking prior to January 1, two adipose marking trailers were used in conjunction with the two coded wire tagging (CWT) trailers. Those fish requiring coded wire tags were adipose clipped during the CWT operation to prevent double handling of fish. After each CWT group was completed, the remaining fish in a pond were adipose clipped. Ten days were required to adipose clip 2,973,776 fish at Dworshak. Over 130 different temporaries were hired. Two 8-hour shifts were run in each trailer, requiring two supervisors for each shift. Because of mechanical problems, not all trailers were continually in operation. Extensive moving of the mobile units was also necessary. The operation, however, was highly successful, and an average of 297,377 fish were clipped (sometimes tagged and left-ventral clipped as well) per day. This translates to 24,781 fish per hour being marked.

In general, fish at all four facilities appeared healthy and in good condition. However, viral disease was confirmed at Niagara and Dworshak during marking. Fish in infected raceways were marked last at both facilities to prevent the spread of disease. Initial marking mortality at all facilities was 0.0632 of the total fish marked. Initial clip quality checks at the southern hatcheries indicated less than 12 were not clipped. Visual quality checks were taken at Dworshak because of time limitations. Sampling for quality checks was done prior to release. Table 1 summarizes the results of the quality checks from the four facilities, as well as the 1987 clipping operations.

Table 1. Summary of Idaho hatchery steelhead adipose fin marking operations, 1987.

	Niagara Springs Hatchery	Hagerman National Hatchery	Magic Valley Hatchery	Dworshak National Hatchery	Total
No. of fish marked	2,300,818	1,986,060	2,116,071	2,973,725	9,376,725
No. of days required	18	13.5	15.33	10	56.83
No. of man hours required[a]	3,456	2,592	2,943	3,096	12,087
No. of fish clipped/man hour[b]	665.7	766.2	719.0	950.5	
Initial clipping mortality	1,711	941	883	2,685	6,220
Percent mortality	.074	.047	.042	.090	.063
Percent acceptable clzps[c]	99.76	99.90	99.88	97.79	99.85

[a]Markers only.

[b]At Niagara Springs, Hagerman Natl., and Magic Valley, two 6-hour shifts were operated out of one marking unit. At Dworshak Natl., two 8-hour shifts were operated out of two ad-marking units. Additional fish were marked in conjunction with tagging operations in two CWT trailers.

[c]Quality checks are initially taken during the mark operation, except for Dworshak, which is a final quality check at release.

1983-1988 Mark Operations

During the five years of the project, nearly 34 million steelhead trout were adipose clipped. Final hatchery releases of clipped fish totaled 30,121,306. During this period, BPA contract expenses totaled $441,000. The total cost of adipose clipping (based on total hatchery release) over the five-year contract was $14.65/thousand. Table 2 summarizes the five years of marking operations.

1985 Clip Healing Studies

Observations of fish in the raceways at all hatcheries indicated complete healing of the tissue in the area of excision within 3 to 4 weeks. Fish that had been clipped too deeply usually showed signs of fungus within one week. There were also observed cases of nipping at the excised white area. In severe cases, fish with fungus died and accounted for the largest percentage of the observed delayed mortality. Mortality from this cause ended within four weeks. Observation from the in vivo test at Dworshak National Fish Hatchery indicated healing was rapid and complete within 22 days (Pat Chapman, IDFG, personal communication). From observation and photographs, there was no apparent difference in the various full and partial clips in terms of regeneration or healing.

Adipose Fin Histological Examination

Histological analysis for both juvenile and adult steelhead trout showed the adipose fins to be composed primarily of fibrous connective tissue interspersed with few blood vessels and occasional adipose (fat) cells. Special connective tissue stain demonstrated a high percentage of collagenous fibers typical of fibrous connective tissue. There was no evidence of glandular or secretory epithelial cells which could be associated with hormonal production. There were no differences in the composition of fins from juvenile and adult steelhead trout (Charlie Smith, personal communication).

Returning Adult Clip Quality

Adult steelhead returning to various hatchery spawning racks during 1986 and 1987 were examined for adipose fin clips. Only those fish of obvious hatchery origin (i.e., irregular fin rays) were included in the samples. At Dworshak in 1986, 33 out of 701 one-salt fish examined had adipose fins, or 4.72. In 1987, 13 out of the 293 examined (4.4%) of the one-salt fish had adipose fins. An examination of 4,869 two-salt fish in 1987 showed 196 with adipose, fins for a 4.02 adipose fin retention. In 1988, 3,784 adult steelhead were examined, and 152, or 4.0%, were nonadipose clipped. An age class breakdown was not available for the 1988 returning fish.

Table 2. Five-year adipose marking summary for Idaho hatcheries, 1983-1985.

	1984	1985	1986	1987	1988
Hagerman National					
No. fish clipped	NA[b]	1,421,6	1,836,058	1,777,997	1,986,060
x acceptable clips		99.30	99.70	99.35	99.90
Total hatchery mortality		__c	183,137	256,372	274,123
Total hatchery release	1,162,475	1,526,932	1,652,921	1,521,625	1,711,937
Niagara Springs					
No. fish clipped	NA	2,502,125	2,291,784	1,928,982	2,300,818
X acceptable clips		99.70	99.70	99.30	99.76
Total hatchery mortality		483,592	611,931	77,082	511,792
Total hatchery release	1,822,805	2,018,533	1,679,853	1,851,900	1,789,026
Dworshak National					
No. fish clipped	NA	2,436,7	3,261,429	1,955,144	2,973,725
X acceptable clips		99.30	99.33	99.36	97.79
Total hatchery mortality		835,028	312,952	--~	271,498
Total hatchery release	1,961,392	1,601,6 95	2,948,477	2,105,748	2,702,227
Magic Valley					
No. fish clipped	--	-- --		--	2,116,071
X acceptable clips	---	--- - --_ _ -(NEW FACILITY)		----------	99.88
Total hatchery mortality					52,311
Total hatchery release					2,063,760
Year total (hatchery release)	4,946,672	5,147,160	6,281,251	5,479,273	8,266,950
Grand total (hatchery release)	30,121,306				

[a]Total hatchery mortality includes all mortality monitored from time of marking to release. All post-marking mortality may not be directly related to the mark operation.
[b]Mark data and mortality not available because of multiagency involvement and program was not in place at time of marking. All steelhead in Idaho were clipped prior to release.
[c]Difference due to disagreement in either count and/or hatchery inventory. All fish on-station were clipped.

uality check samples were taken at the Pahsimeroi, East Fork, Sawtooth, and Oxbow return racks in 1988. These fish were released from Hagerman National and Niagara Springs hatcheries. At the Pahsimeroi facility, 1,094 fish were checked, and 8 had unacceptable clips, for a 0.73% adipose fin retention. At Sawtooth, 837 adult steelhead were examined, and 5 bad clips (62) were found. At the East Fork trap, 190 fish were examined, and none were found with adipose fins. Adult steelhead were examined at Oxbow Hatchery, and 43 out of 2,524 (1.7%) were found to be unclipped hatchery-reared steelhead. Fifty-six fish (4.32) were identified as wild/natural at Oxbow. The relatively higher numbers of unclipped fish may have resulted because of straying from Oregon hatcheries, where not all returning hatchery fish had been clipped (Rich Carmichael, personal communication). Analysis of mark data to determine the actual percentage of adipose fin retention on Idaho stocks will not be available until late 1988. In 1986, 0.32 of the returning adult fish at the Pahsimeroi still had intact adipose fins. Data is not available for the other sites in 1986 or any site in 1987.

Hatchery Versus Wild Adult Returns

A complete analysis of the present and future status of wild and hatchery steelhead trout in Idaho is beyond the scope of this project. Personnel from various state and federal agencies are involved with monitoring both run segments as they enter the Columbia River and migrate into Idaho and through the numerous fisheries. The percent composition of hatchery and wild fish at Lower Granite Dam, based upon dorsal fin erosion, was determined in 1984. That fish run had no clipped fish from this project but was 242 wild. The next year, 1985, scale analysis showed 23% of the fish were wild. In 1986, scale analysis showed the wild run segment at 20.4% of the total run.

DISCUSSION

Mark Quality

The experiences during the past five years demonstrate that an entire state's steelhead production can be marked in an efficient manner. Quality checks on adults returning from fish released from southern Idaho facilities consistently indicate about 1% of the returning adults have adipose fins that were missed in the fin clip operation. However, at Dworshak, the percent of missed adipose clips is higher (near 4%).

The total number of fish unclipped at Dworshak is partly due to crowding problems during mark operations which are associated with design problems with the Burroughs ponds. It is difficult, if not impossible, to remove every fish from the ponds because of the rounded corners and fill pipes located at the outer corners. Extra care is taken, but smaller fish, in particular, can elude the crowd rack by going among the pipes. Additional complicating factors include: 1) Fish are often larger than

those at other facilities at the time of marking. The larger size makes it difficult for the markers to handle the fish, and a few can slip from the marker's hands and escape into the return pipe inside of the trailer without being clipped. 2) There is usually a wide size variation in the fish. In some years, the percentage of "pin heads" is high in comparison to the southern facilities because "drop out" usually has not occurred. The adipose fin is easily missed on these fish (less than 60 mm in total length) when marked with fish exceeding 150 mm. 3) Crowd screens must be of a large enough mesh to prevent clogging during marking operations. However, this size also allows some pin heads to escape and go unclipped. 4) Fish escape to the river in normal hatchery operations prior to marking. This problem occurs at all facilities to a minor degree during the course of normal hatchery operations. Fish escaping at the southern facilities are prevented from migrating to the ocean because of several migrational barriers. Only those fish escaping at Dworshak have the potential of migrating and entering the fishery.

The number of unmarked fish due to any of the above factors is variable. Those factors associated with "pin heading" are quite minor since there are indications these fish do not survive to migration. However, the combination of operational errors inside the marking units and at the hatchery due to either handling or design can result in missed fish. It may be difficult to ever obtain better than a 96% adipose-clipped population at Dworshak. Although the percentage of missed clips at Dworshak is almost four times higher than other facilities, it does not present serious problems to the management and protection of the wild runs into the Clearwater River. The total number of harvestable hatchery fish is relatively low.

Effect of the Program on Wild Runs

It is premature to conclude the degree of effectiveness of the adipose marking program in preserving wild runs into Idaho. The wild runs seem to be increasing as determined by the percent composition of the runs, especially for the 1987-1988 fish run. However, the increase in the wild/natural population is probably a function of several programs giving results. The limited protection given wild adults by the dorsal fin regulation, adult outplantings, and fry plantings are all contributing to a wild/natural comeback. Certainly the adipose marking program is protecting wild stocks in Idaho by eliminating excessive harvest, especially in the early part of the season when wild fish are most vulnerable in areas of high fishing pressure. McArthur (1988), in a telephone survey he conducted statewide, estimated that during the 1987 steelhead season, there were 13,152 wild fish released as a direct result of the adipose fin regulation. Though some fish could have been caught and released more than once, the impact of the adipose fin regulation initiated by this project will undoubtedly have a major positive impact on Idaho's wild steelhead runs in the future. But because of the life history of the fish, it will be 1995 before the full impact of this program can be evaluated.

Clip Healing

Healing of the area of excision is dependent on several factors, including fish health, water quality and temperature, and size at clipping. Larger fish tend to expose more tissue (white area) and usually suffer higher losses due to nipping, which turns into "sore back." Less "sore back" is observed when fish are clipped at smaller sizes. Clips which are too deep expose even more tissue area and result in severe cases of nipping and "sore back." Secondary infections, such as fungus, also result from too deep a clip. In these cases, the fish usually never heals, and death occurs within one month.

Water temperature is critical and can be beneficial or detrimental. As a rule, fish tend to heal faster in warmer water (10^{0}F), but fungus and secondary infections usually increase. Conversely, fish in cold water (1 to 5°C) heal more slowly but show less signs of fungus and secondary infections. Fish marked in cold water temperatures appear to take the stress of the handling operation better, and fewer mortalities result.

In general, fish heal remarkably fast, and from observed and in vivo observations, healing time is not a critical factor in the marking operation. Post-marking prophylactic treatments with quarternary ammonia compounds usually control any complication resulting from the excision of the adipose fin.

Adipose Fin Composition and Purpose

The salmonid adipose fin is relatively small, fleshy, and immobile. It does not contain any skeletal elements, is scaleless, and covered only by the dermis and epidermis. It is filled with an amorphous matrix of loose connective tissue (Harder 1975).

Historically, the adipose fin was thought to be a vestigal fin without purpose and comprised mostly of fatty tissue and thus the name adipose. Weisel (1968) found no fat in sockeye salmon (Oncorhynchus nerka) and only 3 to 4 drops section in the cutthroat trout (Salmo clarki) and brown trout (Salmo trutta). In recent years, there have been several hypotheses that the fin may serve other functions, ranging from hormonal regulation to pH balance. No literature to substantiate any of these hypotheses could be found. The histological examination found no evidence of glandular or secretory epithelial cells which normally are associated with endocrinal or hormonal functions. Stuart (1958) does make mention that the size and shape of the adipose fin is a secondary sex characteristic in spawning salmonids, with the female fin long, thin, and narrow at the base in comparison to a short, thick, wide-based male fin.

Aleyev (1977) suggested the adipose fin in salmonids functioned basically the same as finlets in the Scombriodae (mackeral, tuna, etc.), i.e., it functions to transversely streamline the caudal peduncle for faster swimming.

Fin Regeneration

The practice of fin clipping fish for the purpose of identification has been used for many years. There are many advantages and disadvantages of this type of identification procedure. A question in all studies utilizing fin clipping is whether the fin will partially or completely regenerate, thus rendering the mark difficult to recognize at a later date. Several studies have been conducted to evaluate the regeneration of the various types of fins.

Mears (1976), studying brook trout (Salvelinus fontinalis), found regeneration had occurred in 9Z of all fins observed. The frequency of regeneration was highest (41%) for the anal fin and lowest (9%) for the adipose. Regeneration of the pectoral fins was 1.5 to 2.0 times more frequent than that of pelvic fins. Few fins regenerated to more than 50% of their original size.

Johnson and Shelton (1958) found little regeneration of either adipose or pectoral fins on fall chinook at the Spring Creek Hatchery, with 99.2% of all fish with a double fin mark easily identified as double-marked fish four months after marking.

Stauffer and Hansen (1969) utilized left maxillary, right maxillary, adipose, right pectoral, and right pelvic clips to mark rainbow trout. After two years in the hatchery, 95% or more of the pelvic, pectoral, and maxillary clips were recognizable (one-half or less of the fin regenerated). There was no regeneration of the adipose fin.

Shetter (1951) marked four groups of lake trout (Salvelinus namaycush) with various fin clips. The adipose clip had 5.2% regeneration, the dorsal 6.4%, right pectoral 3.5%, left pectoral 10.2%, and right ventral 35.9% (one-half or more of the fin remaining). However, there appears to be some ambiguity in his reference to the quality of the clipping operation, especially for the right ventral clip.

Hale (1954) found pelvic fin regeneration to be "complete" (both fins similar and normal in size and spread) in 31.5% of the brook trout he held for 14 months 10 days. Most of the remaining fish showed "partial" (one fin club-like in appearance and the other club-like or completely regenerated) or "considerable" (one or both fins somewhat smaller and spreading like a normal fin) fin regeneration (13.7% and 47.5%, respectively). He attributed this high regeneration to inexperience and lack of skill of those clipping small fish (3.0 inches total length).

Other authors have also reported varying results. However, the various studies indicate that the adipose has the least regeneration, with the pelvics next, followed by the pectorals and anal, in respective order. In each study reviewed, a hypothesis was made that a fin with 50% remaining was regenerated. Few studies acknowledged that the regeneration could be aggravated by poor clipping technique. For many studies, the percentage of regeneration may be nothing more than an indication of initial clip quality. Experience and results of marking juvenile salmon

and steelhead for the IDFG coded-wire tagging program has shown that adipose fins properly and totally excised will not regenerate.

Examination of adult steelhead and salmon marked with an adipose clip and coded-wire tag as a juvenile indicates there is no regeneration in a complete clip and only slight regeneration of a partially clipped fin as the incision heals. However, these are usually recognizable as a clip and only when approximately 25% or less of the fin is removed does the mark become questionable. Fish marked with a coded-wire tag and left ventral clip indicate no regeneration of the clip if the fin is clipped below the basal bone. However, leaving only a few fin rays can result in an entire, but usually deformed, fin. Again, the amount of regeneration is directly related to the quality of the clip. In the case of the ventral clip, a poorly applied clip usually results in the loss of information since it is difficult to differentiate a regenerated fin on a hatchery fish from the deformation the fin may have received during rearing.

Stuart (1957) details pictorially the regeneration of partially clipped fins. The observations made in the coded-wire tagging program are basically in agreement with his study.

Marked Fish Survival

Experimentation utilizing marked fish assumes no differential in survival of marked fish and their unmarked counterparts they represent. However, there are studies reporting differential survival of the various clips. A differential in survival may be a result of interference with swimming ability, endurance, behavior, or growth. Other factors, such as handling during marking, physiological condition of the fish at marking, size at marking, and others, may also play an important role.

Bonham (1968) concluded that a maxillary mark on chinook salmon (Oncorhynchus tshawytscha) retarded growth and probably induced mortality and was less desirable than a ventral clip. Wales (1947) found the survival of pelvic-clipped fingerling brook, brawn, and rainbow trout to be better than similar lots of pectoral fin-clipped fish. Shetter (1951) tested the survival of lake trout receiving a single pectoral, single pelvic, or dorsal plus adipose fin clip. After correction for fin regeneration, he concluded there was no significant difference between the survival rates of the marked and unmarked fish. Armstrong (1949) found no difference in the survival rates of unmarked and adipose-clipped lake trout fingerlings after ten months. Experiments conducted by Nelson (1960) indicated that the removal of the pelvic, adipose, or dorsal fins did not significantly affect the survival of fingerling brook or rainbow trout under hatchery conditions. Other authors, such as Ricker (1949) and Foerster (1936), found that marked fish survived significantly less than unmarked fish during their studies. In another experiment, Shetter (1952) found that fin-clipped fingerling lake trout (utilizing the same clips as in his previous work) did not suffer any greater losses from predation than did unmarked fish. Horack (1969) using a stamina tunnel tested the swimming ability of 3.3- to 4.0-inch rainbow trout. He found that swimming ability was not significantly affected by removing either the

dorsal, both pelvic, both pectoral, anal, or adipose fins. He concluded that the removal of both ventral or pectoral fins may reduce stamina and should be used with caution. A caudal clip severely reduced stamina and could affect the outcome of studies. Nicola and Cordone (1973) studied the long-term survival of fin-clipped and unmarked rainbow trout in Castle Lake, California. They found that any fin clip was detrimental. The adipose fin clip reduced survival by as much as 50%. The removal of a ventral fin reduced survival by as much as 60% to 70%. The removal of a pectoral or dorsal fin reduced survival 70% to 80%. The removal of an anal fin was not any worse than the removal of the pectoral or dorsal, but removal had an inconsistent effect. They concluded that the anal fin clip should be avoided unless full excision could be guaranteed.

In the preliminary analysis of the Oregon Coastal Zone Management Association (OCZMA) proposal to mark hatchery-reared coho in the Oregon Production Index (OPI) area in 1984, a special task team evaluated the effects of marking. They concluded that in all experimental cases reviewed, extra handling and stress of fin clipping caused reduced survival. It also appeared that the survival effect went beyond immediate mortality due to stress in the hatchery. Although they could not identify the specific cause, evidence suggested that the removal of the adipose fin causes reduced ocean survival compared to unclipped fish. Loss of other fins or maxillary bones caused even greater losses. From the best available data, they concluded that adipose fin clipping would cause the loss of 52 to 202 of the hatchery coho production compared to unclipped releases. However, the data they present (Table 6, page 23 of the proposal}, with the exception of one group, shows the adipose clip in conjunction with another mark. In almost all cases presented, the groups receiving a second mark in addition to the adipose clip survived less than the one group receiving only an adipose clip. The sources they used to estimate the 5% to 20% mortality for an adipose clip are not cited. Evidence from Idaho's fish marking, coded-wire tagging, and freeze branding operations indicates that mortality increases with each additional mark applied to the same fish.

Though there are many studies documenting marked fish survival and the differential survival between marked and unmarked fish, it appears from the literature available that the removal of the adipose fin affects survival of the fish the least, followed by the pelvics, pectorals, and dorsal. The caudal, anal, and maxillary are the least desirable to use, and studies indicate they may significantly affect survival.

CONCLUSIONS

During the first five years of the marking program, personnel have been successful in achieving the marking of essentially all hatchery-reared steelhead in Idaho. During this time, 30,121,306 adipose-clipped steelhead trout have been released. Marking mortality during this time has been minimal, although total hatchery mortality prior to release in some situations is high, mainly because of viral diseases. Although wild runs appear to be increasing, the full effect of this program cannot be evaluated until the mid-1990s. However, in the interim,

the program is protecting wild stocks from being harvested in Idaho and allowing for successful harvest of hatchery stocks in a mixed-stock fishery.

The adipose fin mark is economically applied to large numbers of fish with minimal stress and mortality, affords a permanent and readily identifiable mark with good angler recognition, and provides for an easily enforced regulation. If all agencies and tribes in the Columbia Basin would participate fully by marking all hatchery-reared steelhead, wild/natural stocks could be protected in sport fisheries and more accurately accounted for in gill net fisheries. Adipose marking of hatchery steelhead will be continued in Idaho's fish hatcheries.

BIBLIOGRAPHIES

The bibliographies presented are by no means complete. They are compilations from several research projects, books, and journals. Paul Mongillo (1984) and Victor A. Lewynsky (1980) both have done extensive reviews of literature on hooking mortality. Their work, along with others, is included.

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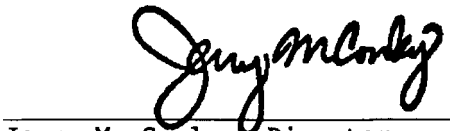

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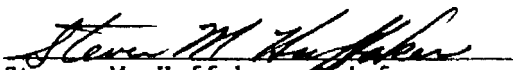

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